INTERNET OF THINGS: DOMESTICATED TOOLSETS FOR SOLVING MAJOR CHALLENGES FACED BY INDIVIDUALS WITH HEALTH PROBLEMS

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ABSTRACT

In this modern era of globalization, technology has increasingly infiltrated all aspects of human life. Health is no exception to this advance. Provision of health services has undergone evolution to reach the current status. However, many people, especially in developing countries, do not enjoy optimum health services due to several constraints. This is where technology continues to grow and be beneficial for all strata of society. From the direct provision of health services, technology can also help to prevent, optimize diagnosis, and treatment of diseases. One of the latest breakthroughs in health service provision is the integration of the Internet of Things (IoT). Utilization of IoT is expected to bring a radical change to the provision of health services. This is in line with the principle approach of preventive, predictive, and personalized that so far has not been applied optimally due to limitations and constraints of health resources.

KEYWORDS

Globalization, internet of things, health, quality of life, chronic conditions, companion devices, wearable devices

1. INTRODUCTION

Internet of Things (IoT) in healthcare has opened up enormous possibilities to enhance all areas of healthcare. However, it's important to help direct and shape the use of IoT within health to maximize benefits. The introduction of IoT into health has coined the term the Internet of Medical Things (IoMT) to describe the collection of medical devices and applications that connect to healthcare IT systems through online computer networks (Aghdam et al., 2021). IoT has been defined by the International Telecommunication Union (ITU) as providing the infrastructure for the interconnection of everything from vending machines and ATMs to home entertainment devices like television sets, DVD players, and set-top boxes. This can be achieved through embedded devices that communicate and control each other (Naresh et al., 2020). This is just the start of what has been proposed for IoT.

1.1. Background and Definition of IoT

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The concept of the IoT was first introduced in 1999 by Kevin Ashton. IoT is the network of physical objects or things embedded with electronics, software, sensors, and network connectivity enabling them to collect and exchange data (Amin & Hossain, 2020). In a more simplistic manner, IoT can be described as follows: The 'things' in IoT are the essential equipment and gadgets used in our daily lives. These gadgets, through some electronic chips and sensors, transfer the data onto a main server where the data is stored and then finally processed. This data is then used to understand the behavioral aspects of an individual using these gadgets. This behavioral data analysis would serve as evidence to help understand changes in behavioral patterns when an illness or disorder has developed (Ratta et al., 2021). An example to describe this would be the use of a smartphone fitness application. Nowadays, people have various mobile applications that help track their daily fitness routine. These apps, through electronic data-saving techniques, save the information of your fitness regime. Now, imagine if an individual were to fall ill and develop a disorder, there would be a significant change in the fitness regime. The previous data, when compared to post-illness data, would show a noticeable difference. This is how IoT stores and analyzes data to show changes in behavioral patterns due to an ailment.

In today's world, wearable gadgets are increasingly becoming popular due to the convenience they offer. These gadgets range from fitness trackers to smartwatches and various other types of trackers (Qadri et al., 2020). These devices can all be implanted with a sensor. Now, the data collected via these sensors would exhibit a trend of day-to-day activities of an individual. This data is particularly useful to understand the physical behavioral aspects of an individual. This trend data can exhibit changes in lifestyle, effects of certain food habits, long working hours, etc. This kind of trend data is particularly useful to prevent lifestyle diseases. In the case of developing an illness, disease, or disorder, this data can help health professionals compare the pre and post-illness conditions and give necessary recommendations to revert the condition. The fitness application and trend data are very minute examples and the tip of the iceberg to what possibilities IoT can offer to understand behavioral patterns (Ansari et al., 2020). The scope of applying such devices and gadgets is immense in understanding people with mental illnesses, disorders, and various disabling conditions. With necessary advancements, IoT can offer precise data analysis to tailor-make treatment packages for individual patients.

1.2. Importance of IoT in Health

The use and implementation of IoT has been one of great interest by researchers and technologists in a wide array of fields. IoT in the healthcare field offers a variety of ways to track and manage health for individuals (Kishor & Chakraborty, 2022). This can be done using wearables such as watches or tracking devices which can monitor and send health information to a database for health professionals to monitor and make informed decisions on. One of the aims of healthcare IoT is to provide the correct data to the correct person at the correct time. One significant way that this is being done is through the use of real-time health systems (Thilakarathne et al., 2020). An example of this is a system tracking the health of an individual recovering from surgery in their home rather than a prolonged stay at the hospital. This can free up hospital beds for those who truly need them and avoid hospital-acquired infections which can be detrimental to a person’s long-term health. Tracking systems can also monitor for changes in patient condition and alert health professionals to make a timely intervention (Kishor & Chakraborty, 2022). This can be a means of preventing readmission to the hospital.

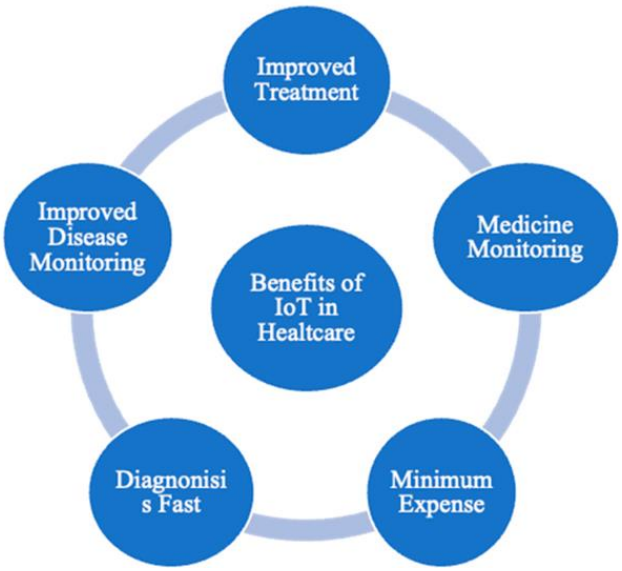

Figure 1: Value of IoT in Medicine

1.3. Challenges Faced by Individuals with Health Problems

Elderly individuals or patients suffering from chronic diseases face various health challenges and frequent visits to healthcare providers and facilities for monitoring their health status. Such constant monitoring has proven to be expensive, with hospitalizations due to exacerbation of chronic diseases accounting for a large portion of healthcare costs (Rejeb et al., 2023). Increasing emphasis is being placed on keeping the chronically ill at home and in the community to prevent avoidable hospitalization. However, there is often a lack of timely and effective intervention before health crises develop. These individuals often have physiological data that is useful for monitoring their health status. Unfortunately, this data is often not acted upon in a timely manner to change the care plan. Finally, there is a need for early detection of health issues so that timely interventions can be provided to prevent the onset or exacerbation of health problems (Sharma et al., 2021). IoT can address the aforementioned challenges faced by these individuals by providing continuous monitoring of physiological data in a timely fashion, facilitating the communication of this data to those who make care decisions, and automatic detection of changes in health status that may require a change in the care plan (Amin & Hossain, 2020). By providing the tools to improve self and formal care, IoT has the potential to improve the health and quality of life for these individuals.

2. LITERATURE REVIEW

2.1. Monitoring and Tracking

Remote health monitoring refers to the use of a variety of technologies to support the care given to patients outside of clinics or hospitals. According to Kashani et al. (2021), it enables the collection, transmission, evaluation, and communication of patient health data using electronic devices to healthcare professionals located at a distant site. This approach has a number of applications and can be applied to the chronically ill, the elderly, those with long-term disabilities, individuals recovering from surgery, and to healthy people. It is an effective way to prevent and manage the emergence of chronic health conditions which require costly and lengthy treatment. This approach is also crucial to support the independence and quality of life for the

growing population of elderly people. Somasundaram and Thirugnanam (2021) assert that IoT can greatly improve this method of healthcare with the use of wearable devices and mobile phones. For example, a person with a heart condition may wear a wearable electrocardiogram (ECG) device that can transmit data to a server. The data can then be evaluated, and if a heart anomaly is detected, the person can be notified and advised to seek medical help. This is a more comprehensive and proactive method of monitoring health. Another example is a hypothetical system called "iScheduler" that can be implemented to help the elderly easily manage their doctor's appointments (Sharma et al., 2021). It could send an SMS reminder to the mobile phone of the appointment time. If the appointment is not confirmed, the system can notify the person's children. The patient's status can be monitored, and if an alternative form of transportation is possibly due to license restrictions, the appointment time can be rescheduled (Kashani et al., 2021). This kind of system can greatly improve communication between patients and healthcare providers and reduces the risk of missed appointments and no shows.

2.1.1. Remote Health Monitoring

Remote health monitoring can prevent clinical events, improve the effectiveness of treatment, and increase the patient's functional capacity and quality of life. According to Somasundaram and Thirugnanam (2021), an intelligent remote monitoring system will track the physiological parameters that are most sensitive to deterioration in the patient's condition and which indicate the effectiveness of specific interventions. High-frequency tracking is essential for early detection of clinical events. This can reduce the frequency of expensive consultations and inpatient treatment. The ultimate level of monitoring is achieved through in vivo measurement of a biomarker that provides an indication of disease activity and an early signal of its exacerbation (Kelly et al., 2020). Early detection and intervention can prevent or modify the course of a disease, thus avoiding the clinical events that would otherwise have occurred. This concept has been demonstrated in recent randomized controlled trials of disease management in heart failure and diabetes.

Current healthcare practice is for diagnosis and treatment to occur when a patient's condition reaches the stage where it is clinically apparent and medical intervention is required. Kelly et al. (2020) also explain that treatment is then aimed at halting or reversing the progression of the disease. At this point, the costs, both in terms of finance and a compromised quality of life, can be substantial. When successful, these measures can eliminate the clinical symptoms of a disease or arrest further progression, but the underlying pathological process often continues (Bhuiyan et al., 2021). This can lead to a recurrence of symptoms and further acute episodes requiring medical intervention. These, in turn, can lead to a progressive decline in the patient's functional status and independence.

2.1.2. Wearable Devices for Health Tracking

Activity monitors have been commercially available for the last few decades, from the traditional pedometer to the more advanced accelerometers. These devices are used to track users' physical activity in the form of steps taken throughout the day. Data acquired is useful in motivating sedentary individuals to increase their physical activity levels (Ajayi et al., 2024). This type of monitoring should not be confined to individuals with established health conditions but used preventatively to detect abnormalities. The emergence of 'hearables' that fit in the ear, as well as the development of a range of smartwatches, have introduced new methods of monitoring health parameters, including heart rate, blood pressure, and oxygen levels. The smartwatch form factor is well accepted, and these devices offer the ability to provide real-time feedback as well as collection and storage of data (Adigwe et al., 2023). Electronic exercise diaries have been used to record the type, intensity, and duration of exercise. These diaries can be tedious, and often

activity is forgotten or recorded inaccurately. Wearable heart rate monitors offer a more objective and accurate method of monitoring exercise intensity. According to Somasundaram and Thirugnanam (2021), this data can be stored and used to inform health professionals. Wearing uncomfortable straps and the lack of real-time feedback has limited the adoption of this technology.

2.1.3. Smart Home Health Systems

By monitoring the physical and physiological state of the patient, homes can provide important feedback to health professionals to tailor treatment and preventative strategies. Somasundaram and Thirugnanam (2021) assert that these homes can also help to alert health professionals in the event of a sudden and critical change in health status that requires intervention. By automating routine tasks and providing assistance with activities of daily living (ADLs), elders and disabled individuals can maintain higher levels of function and independence. Smart homes can be a tool to help support informal caregiving and offset institutional care costs. Smart home health systems offer significant potential for sustaining and improving the quality of life for the growing number of older persons in the United States. According to Akinkunmi et al. (2024), today's elders want to age in place, which means living in their own home and community safely, independently, and comfortably regardless of age, income, or level of health or ability (Amin & Hossain, 2020). Smart home technology can provide many benefits to assist elders in maintaining their independence and improving their quality of life.

Home is the best place to recover from a disease. Research has proved that the chances of getting a secondary disease at the hospital are higher than that at home (Qadri et al., 2020). Additionally, patients recover faster at home than at the hospital. Considering technological advancements, in the future, patients will be able to recover from almost all diseases at home. Smart home health systems will monitor and track a patient's health condition while keeping them at home. Development of smart home health systems has significant features to monitor and track a patient's health condition. It will help to record a patient's medical history, including current and past illnesses, drug allergies, medications, and results of tests and procedures (Marquis et al., 2024). This information can be stored and used for diagnosis in case of the same disease happening in the future.

2.2. Disease Management

Medication adherence solutions IoT connected medication packaging can be used to monitor a patient's medication adherence. A report from the New England Healthcare Institute places the annual cost of poor medication adherence in the U.S. at $290 billion (Olabanji et al., 2024). It suggests that approximately half of all patients do not take their medications as prescribed and that this results in an additional 33-69% of all medication-related hospital admissions. Poor medication adherence is a particular issue for the elderly and those with chronic conditions (Kishor & Chakraborty, 2022). IoT applications such as smart pill bottles can provide audio-visual reminders to take medications and send alerts to care providers or family members if a dose is missed (Qadri et al., 2020). Emerging technologies like digestible or wearable sensors can provide even greater insight into a patient's medication-taking behavior.

Personalized treatment plans IoT applications can supply patient-generated health data directly to a healthcare provider. This can be analyzed against evidence-based guidelines to determine if treatment is effective (Kishor & Chakraborty, 2022). It can also be used to alert a healthcare provider if a patient's condition worsens, enabling earlier interventions. This is likely to lead to a shift away from the traditional reactive care delivered during a face-to-face visit, towards a more proactive continuous care model that aims to prevent negative disease progression.

2.2.1. Personalized Treatment Plans

Personalized treatment plans are designed by considering the patient's health and medical details. A treatment plan is a detailed plan for treating an illness. According to Kashani et al. (2021), it is one of the most important things a patient can do to help them recover, yet many people do not understand how a treatment plan can vastly improve the recovery rate and make a significant difference to the long-term success in recuperation. To form the best plan, it is essential for the health service provider to understand the patient's condition and how this affects their quality of living. This is why the SLP is so conducive in improving a patient's recovery (Kishor & Chakraborty, 2022). By considering the patient's medical history and using IoT to gauge the patient's vital signs to determine the effect the illness is having, resources can be allocated to assess how the patient's condition can be most improved (Ansari et al., 2020). At this point, the healthcare provider and the patient can then decide on the best course of action with the most desired outcomes. IoT is combining the use of wireless technologies in conjunction with modern mobile phone capabilities in developing mobile telemedicine applications to be used with smartphones. By using mobile telemedicine, the healthcare provider can assess the patient's recovery in a home setting. This allows a safe patient environment for the patient and a true reflection of the status of their condition. According to Kelly et al. (2020), with the ability to have virtual consultations, doctors can provide recommendations to make changes to the patient's treatment plan, which will avoid unnecessary trips to the doctor's office. This can provide significant improvements in a current treatment plan for chronic illnesses, which are aimed at symptom management and preventing further functional decline.

2.2.2. Medication Adherence Solutions

A medication regimen is composed of a series of tasks that a patient should carry out to succeed in the desired therapeutic result. The complexity of a regimen can include the choice of medications, the dosage and frequency of every drug, special instructions, and changes to the regimen over time (Olabanji et al., 2024). It has been discovered that the complexity of the medication regimen is inversely proportional to the level of adherence, showing that a more complex regimen often leads to decreased adherence. Typical barriers that patients experience with medication adherence consist of forgetfulness, depression, insufficient disease education, complicated drug regimens, fear of dependency, and advanced age. Our group has an interest in concentrating on the two elements of a complicated drug regimen and insufficient disease education because they are essentially the most conducive to a technology answer (Ansari et al., 2020). Therefore, we sought to realize a comprehensive understanding of the issues as experienced by the patient and the best way to now have an effect on a change within the well-being outcomes by using a patient-centered methodology to improve (Olabanji et al., 2024). Accessing the perspectives of patients and health professionals using qualitative analysis enabled us to evaluate the best way to best support medication adherence and thus health outcomes for patients.

2.2.3. Remote Consultations and Telemedicine

Admission of remote consultations and clinical medicine are among the most established applications of eHealth. According to Kashani et al. (2021), usage has been spread by the incorporation of web wellbeing programs supported by general professionals and has been helpful for both developed and developing nations. The part of healthcare provided remotely has varied across different countries, states, but has often included routine standard procedures of healthcare (Ansari et al., 2020). Various industries have developed and trialed telemedicine technologies, such as diagnosis-specific conferencing, where the patient gets a consultation with a specialist or a team of specialists, medical decision support including the situation where

curative decisions have been made based on medical data provided online, and consumer medical information where the patient gets insight to interpret his own medical information (Olabanji et al., 2024). The ability to provide these types of services in part depends on factors such as the capacity of information transmission available as it is impossible to conduct sound consultation over a low bandwidth, and reimbursement policies as is the case with many developed countries. According to Kelly et al. (2020), telemedicine has aimed to improve indication, patient management and the quality of care provided. Randomized controlled trials have provided evidence to prove that with a system including telemedicine there are improved outcomes in healthcare regarding reduced re-admission to hospital, accelerated pain management and improved effectiveness of treatment. These research findings were reported in a large meta-analysis of trials conducted between 1997 and 2008. While there is evidence to suggest some improved patient outcomes, it is frequently not yet clear as to whether the economic costs involved are reasonable.

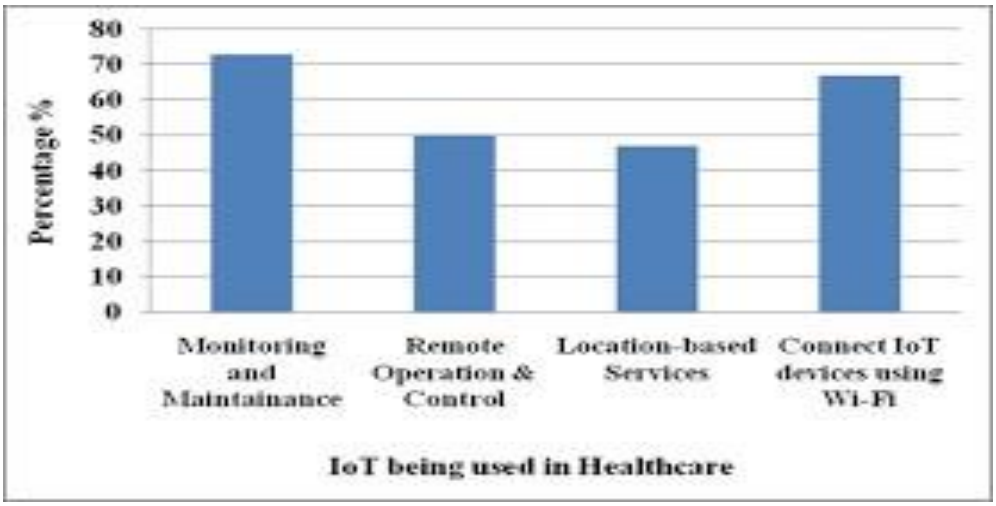

Figure 2: Remote IOT in Health care application

2.3. Emergency Response

Emergency notification devices are specific to at-risk individuals and provide a convenient and simple interface for the user to call for help in emergency situations. Kashani et al. (2021) assert that the most common of these devices are used by the elderly. These come in the form of a button that can be worn as a pendant or on the wrist. When the user feels the onset of a medical emergency or accident, they can press the button to alert emergency services or a specified contact. When GPS enabled, the location of the individual can also be quickly determined. This is highly useful where the individual is unsure of their location or unable to communicate it (Olabanji et al., 2024). These systems are highly effective, yet they rely on the user's ability to manually trigger the alarm and thus are not suitable for emergency situations in which the individual is immobilized or unconscious.

Wearable sensors, such as accelerometers, have the potential to collect data on an individual's movements. By determining an individual's activity levels throughout the day, it may be possible to infer when a person has fallen. For example, one of the changes that may occur following a fall is an extended period of time spent lying down. Kelly et al. (2020) affirms that a system could be designed to continuously monitor an individual's posture and body orientation and detect any prolonged static positions that may indicate a fall. Upon detection of a fall, a device could be configured to automatically contact emergency services and send alerts to specified family

members. In a more advanced system, a fall could be detected and video and audio from the time of the fall could be stored and tagged. This would require a privacy-sensitive audiovisual capture that can be readily activated, yet it does not continuously record and store data (Kishor & Chakraborty, 2022). Using information fusion techniques, such as information from surrounding sound, the system could gain an understanding of the event context, thus helping to distinguish between falls and other events and ultimately providing a higher quality of care. It is important that an alarm system is highly reliable and minimizes false negative rates. For instance, a system that requires the user to manually press a button to confirm that a fall has occurred is inadequate for emergency situations in which the individual may be rendered unconscious.

2.3.1. Fall Detection and Alert Systems

Environmental fall detection is implemented through a network of sensors placed throughout a home or other environment where the individual may be located. The development of this form of detection is still in its very early stages, with most research being conducted within the last ten years (Kishor & Chakraborty, 2022). The sensors will monitor the individual's movement patterns, and if a sensor detects a fall or an irregular pattern such as a lack of movement, an alert can be sent to a predetermined source. The advantage of environmental detection is that no action is required from the individual in order for an alert to be generated (Oladoyinbo, 2024). The major drawback, however, is that it is only effective within the environment where sensors have been placed.

Wearable devices can be a wristband, pendant, belt clip, or any other form of device that can be worn on the body. In the case of a fall, the device will detect the sudden acceleration and deceleration of the body during the fall and the impact with the ground (Marquis et al., 2024). Using this information, the device can determine if a fall has occurred or if the user has just sat down abruptly. If a fall is detected, the device will send an alert to a remote server or third party, and the appropriate action can be taken. The detection of a fall can also be verified with the user beeping the device like a panic button or, in some cases, the device will attempt to verbally make contact with the user. Fall detection and alert systems represent one of the most valuable tools provided by the IoT for elderly individuals (Kashani et al., 2021). There are two general types of systems implemented frequently: wearable devices and environmental sensors.

2.3.2. Emergency Notification Devices

Another type of automatic alert system was designed to link physiological data with subjective symptoms from the user. According to Kashani et al. (2021), if the data triggered a concern for an abnormal health event, the system would automatically place a telephone call to a registered nurse who would assess the user's condition. This system was tested in randomized trials involving adult patients with non-cardiac diagnoses and revealed that it was a feasible method to collect and transmit data and reduced the time it takes for a patient to seek medical attention.

The first studies of emergency notification devices tested devices that detected irregular heart rates and would alert the user to check their pulse. If the user was unable to locate a pulse, the device would activate a public switch telephone network (PSTN) to summon emergency medical services (EMS) and notify family members (Omogoroye et al., 2023). This device was tested over a 2-year period, and the data collected concluded a reduction of 26% in the use of acute medical services and an increased feeling of security and confidence in living alone.

Researchers have spent many years testing emergency notification devices to help those in urgent situations. According to Marquis et al. (2024), the devices work by allowing the individual to press a button, sometimes a specific button, or trigger a sensor due to an irregular health event

that then sends a notification to family, friends, or emergency services. The emergency notification devices primarily used by seniors are meant to signal the onset of a medical emergency and summon the appropriate assistance (Oladoyinbo, 2024). These devices offer a sense of security and independence to the individuals who use them, and the benefits of these devices have been known to save lives and reduce the length of hospital stays.

2.3.3. GPS Tracking for Lost or Disoriented Individuals

There are a variety of devices with differing functions for this purpose. For example, a small device that can be worn as a pendant, a watch that is robust and water-resistant, or a device that can be discreetly placed in an item of clothing (such as sewn into a pocket) (Marquis et al., 2024). These devices are lightweight and comfortable to wear and should therefore not disturb the individual from going about their daily routine. The family or carers of the individual will have access to a web-based application or the service provider's own application, which can be accessed from a smartphone or tablet device. This interface will provide features such as location on demand, real-time tracking, location history, geo-fence zones, and various alerts and reports. Other GPS tracking devices are also available to be used with smartphones to provide a higher level of outdoor safety for those that may be at risk and more independent (Oladoyinbo et al., 2023). This type of IoT-based solution is a cost-effective and highly advanced with a simple and easy-to-use solution.

The GPS tracking system has the capability to track the location of a small lightweight device on a programmed interval, with the latest and most advanced devices being able to track the device in real-time. Should the tracked individual wander outside of a pre-defined area, the device has the ability to raise an alarm and alert designated carers or family members. This technology can help to reduce the need for 24-hour supervision on those that may be prone to wandering, such as Alzheimer's sufferers.

2.4. Assisted Living

Assisted living is a very important aspect of health, especially for the aging and those with disabilities. A major part of assisted living is the ability to maintain independence without the assistance of a nurse or loved one. Smart home automation is a great way to give those that need assistance an increased level of independence (Marquis et al., 2024). A smart home is one that is monitored and controlled by a computer. For the elderly or disabled, smart homes can provide a newfound level of self-sufficiency through automation. By having a system that automatically controls window shades based on the time of day, the individual will no longer have to worry about blinding sun or the difficulty of going to each window in the home to pull a shade. This technology could prove very valuable to those with vision impairments (Kashani et al., 2021). Other common automation systems such as automatic temperature control and turning lights on or off can be very helpful to those that have difficulty getting around. Smart home automation is a growing field with very positive implications for the future of healthcare in the home. Voice activation is a simple and efficient way for individuals to perform tasks without having to physically exert themselves. Voice control systems can be implemented to control any automation system in the home by simply speaking a command to the computer. Short of the automation of an entire house, voice control can also be used to control specific devices (Oladoyinbo et al., 2024). A good example of this would be a television remote control. Imagine an individual that has difficulty using their hands, with a voice-controlled remote they would no longer have to struggle to press a button or reach for a wall-mounted switch. Voice activation has a very high potential for helping those with various disabilities and can be an affordable solution.

2.4.1. Smart Home Automation for Assistance

Smart home technology is very flexible and can be adapted to many different complex scenarios involving elderly and disabled individuals. ADL (Activities of Daily Living) monitoring is a simple concept involving the monitoring of individuals in their own homes (Omogoroye et al., 2023). ADL monitoring systems record events that occur in the smart home, where an event is a triggered smart home device that is time stamped, e.g. a sensor detecting the opening of the refrigerator door. ADL monitoring can be used to detect changes in behavior or health status of a person, and can be used to provide indications that would enable an early response to preventative care. ADL monitoring systems can also be used in the remote care scenario, giving peace of mind to relatives of the individuals being monitored (Oladoyinbo et al., 2024). ADL monitoring solutions can be provided in accordance with a developed smart home technology to give a versatile and effective monitoring system for the elderly and disabled.

An assisted living environment is the ultimate, final intelligent space application. The purpose of an assisted living smart home is to provide consumers with a supportive living environment that enables them to remain independent and increases their quality of life (Kishor & Chakraborty, 2022). The smart home of today has already made significant strides toward enabling the elderly and disabled individuals to live better quality lives. Remote healthcare and ADL monitoring in smart homes extends the time an elderly person can live in their own home rather than move to a medical facility. Smart home technologies help people with disabilities to become more independent by automating the electronic control of the home allowing them control of the environment. Somasundaram and Thirugnanam (2021) explain that smart home automation has a future in providing a proactive assistance environment. This means having devices that sense the user's intentions and act on them without further instruction.

2.4.2. Voice-Activated Assistants for Daily Tasks

Another area where voice-activated assistants can provide aid is for individuals with visual impairments. Traditional smartphones, tablets, and computers rely on visual and tactile interfaces (Kishor & Chakraborty, 2022). Many tasks such as reading email, checking the weather, or finding a recipe for dinner are much easier with vision. Voice-activated assistants are a hands-free interface to access information and perform tasks. In a smart home environment, the assistant can notify the individual of important information such as severe weather alerts or calendar events. The assistant can also walk the individual through the use of other smart home devices (Somasundaram & Thirugnanam, 2021). For example, it can help set the thermostat to save energy or program the settings on a new home blood pressure monitor.

This concept of passive monitoring and intelligent decision support can be extended to a system to remind individuals to take their medications. According to Somasundaram and Thirugnanam (2021), forgetfulness in medication adherence is a common and costly problem. It can lead to a worsening of chronic diseases and cause hospital re-admission. In a smart home environment, IoT devices can passively monitor when medications are taken using RFID tags or smart dispensers. If a dose is missed, the system can send an alert to a voice-activated assistant to remind the individual to take the medication (Omogoroye et al., 2023). If the alert does not result in action, the system can notify a family member or healthcare provider to intervene.

Voice-activated assistants have been popular in recent times with the proliferation of devices such as the Amazon Echo and Google Home. These devices are being used in IoT health research to provide assistance to individuals with cognitive impairments (Kishor & Chakraborty, 2022). For example, individuals with traumatic brain injury or early onset dementia may be unable to complete complex tasks. These assistants can provide step by step verbal instructions to walk the

individual through a task. Additionally, if the assistant is integrated with smart home devices, the assistant can ensure that the task is completed properly. For example, if the task is to prepare a meal, the assistant can check that the oven is turned off after the meal is prepared. If the oven is still on later, the assistant can remind the individual to turn it off (Kishor & Chakraborty, 2022). The passive monitoring capabilities of IoT devices can be coupled with intelligent decision support provide an extra layer of safety for individuals with cognitive impairments.

2.4.3. Social Interaction and Mental Health Support

IoT devices can also provide assistance in monitoring and alarming mental health patients who may be in danger of harming themselves. A certain negative behavior in patients suffering from dementia is to express an urge to wander off (Kishor & Chakraborty, 2022). This may be hazardous if they become lost and can endanger themselves. The traditional method to prevent this is to place physical restraints, but this only provides discomfort and does not fully prevent the risk. GPS technology and RFID tags now provide an alternative to this with live tracking of the person and an alarm if they stray too far from a set location (Ajayi et al., 2024). For example, the company Black Line has a small GPS device worn by the person, and the Silent Saver is a home-based unit with the ability to track and set defined boundary areas around the house.

With the effectiveness of potential companionship of IoT devices, mental health conditions could also be alleviated and prolonged. A research conducted also reported that certain individuals with mental health issues "found the companion ARIES to be extremely positive with one participant even going as far as to say that the device had 'changed his life' (Ajayi et al., 2024). ARIES is an animated 3D IoT avatar designed to engage conversation with the person. Throughout the 3-week study, it was recorded that the daily positive mood of participants increased from 25.56% to 33.44%, signifying that any form of interaction can give a positive impact on mental wellbeing. Patients with Alzheimer's disease could also benefit from interaction with robotic companions. PARO is an advanced interactive robot developed by Japan, resembling a baby seal. It is installed with intelligent technology that allows it to perceive and respond to people and its surrounding environment (Omogoroye et al., 2023). It also learns to behave in a way that its actions are rewarded, causing favorable actions to be learned. Studies found highly positive results between encounters of PARO in patients and the decrease in neuropsychiatric symptoms drawn from a comparison with a control group.

3. METHODOLOGY

A sample of 30 participants using different IoT devices were selected randomly for the purpose of this study. To determine the relationship between the use of IoT devices and improvement in blood pressure, a regression analysis was used. The independent variable is the duration that a participant has used an IoT health monitoring device and the dependent variable is the improvement in blood pressure. A scatter plot and regression analysis were done.

4. RESULTS

The results of scatter plot and regression analysis are presented in figure 1 and tale 1 below

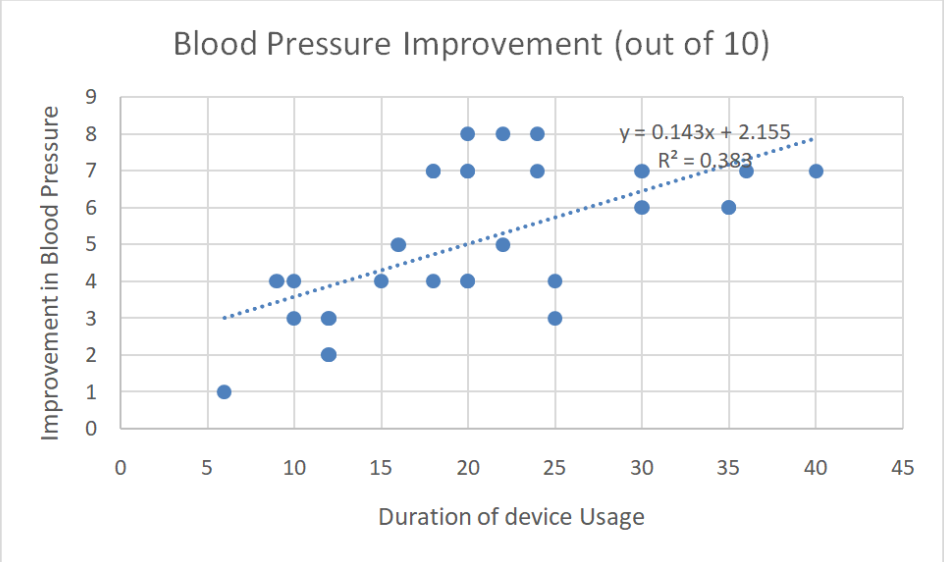

Figure 1: Scatter plot

Table 1: Regression output

SUMMARY OUTPUT						
Regression Statistics						
Multiple R	0.619220135					
R Square	0.383433576					
Adjusted R Square	0.361413346					
Standard Error	1.616725466					
Observations	30					
ANOVA						
	df	*SS*	*MS*	*F*	*Significance F*	
Regression	1	45.51356545	45.51357	17.41279	0.000263909	
Residual	28	73.18643455	2.613801			
Total	29	118.7				
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	2.155623155	0.76485267	2.818351	0.008759	0.588893483	3.722352828
Duration of Device Usage (months)	0.143394976	0.03436369	4.172863	0.000264	0.073004149	0.213785803

5. DISCUSSION

A scatter plot for the two variables showed that there is a moderately strong positive linear relationship between the two variables. To verify whether the relationship is significant, a regression analysis was conducted. From the regression analysis, a p-value of 0.008759 was obtained which is less than the level of significance of 0.05 meaning the relationship between the duration of usage of IoT devices and improvement in blood pressure is significant. The fitted line of best fit is y = 0.1434x + 2.1556 where y is improvement in blood pressure and x is the duration of using IoT device for health monitoring. The coefficient of determination was 0.3834 implying the model can only explain 38.34% of the variation in the variables. This means there are also other variables directing the variation

6. CONCLUSION

IoT has significant importance in the health sector. This is due to the complex health problems that always come with a variety of patient groups. The targeting benefit of IoT can also be customized for each individual to better reflect the issue of more precise health problems, preventive measures, and corrective actions taken. This is in line with the adoption of a pattern of preventive, predictive, and personalized to improve public health status. By IoT, the cost of certain treatments can also be reduced. An example is the use of a particular drug to treat a disease in a particular patient. Its effectiveness and impact on the disease process can be known, so it can be seen if the drug does not give a bad impact and needs to be discontinued. This can be done by comparing the health data stored with IoT without having to repeat the same examination. IoT is a modern concept in which objects, animals, or humans are given the ability to perform transfer of data using a network without needing human-to-human or human-to-computer interaction. This is due to the prospect of improving and adding efficiency to human life. In the health sector, the IoT has the potential to connect patients to healthcare providers and data resources, while providing remote monitoring of vital signs and other health data. This is expected to increase the opportunities for early diagnosis and treatment. The use of IoT may provide automatic alerts and information on the origin of a disease process and give information on various possible treatments.

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